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The association between inflammatory back pain characteristics and MRI findings in the spine and sacroiliac joints

Original article

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ABSTRACT

Objective: To investigate the association between MRI findings at the sacroiliac joints (SIJs) and vertebral endplates and pain characteristics assumed to be indicative of axial inflammation.

Methods: Patients aged 18-40 years with persistent low back pain referred to an outpatient spine clinic participated, including an unknown proportion of axial spondyloarthritis patients. Data included MRI of the spine and SIJs and self-reported responses to questions covering the Calin, Berlin, ASAS and Bailly inflammatory back pain (IBP) definitions.

Results: In the 1,020 included patients, 53% were females and the median age was 33 years. Positive associations were found between the SIJ MRI findings and pain characteristics, odds ratios ranging from 1.4-2.7; 'SIJ bone marrow edema (BME)' was associated with 'morning stiffness >60 minutes', 'SIJ erosions' with the Calin, Berlin, and Bailly IBP definitions, 'alternating buttock pain' and 'good response to NSAID'; 'SIJ fatty marrow deposition (FMD)' with 'insidious onset'; and 'SIJ sclerosis' with 'pain at night'. Also, the spinal MRI changes were associated with IBP, odds ratios ranging from 1.4-2.0; 'vertebral endplate BME' with, 'morning stiffness', and 'vertebral endplate FMD' with the Calin and Bailly IBP definitions, 'improvement with exercise', 'morning stiffness >30 min' and 'pain worst in the morning'.

Conclusions: The identified associations between inflammatory MRI findings and pain characteristics indicate that axial inflammation to some degree induces a specific pain pattern. Thus, the results add to knowledge of axial inflammatory processes. However, all identified associations were weak, which compromise the use of IBP as a marker of axial inflammation.

SIGNIFICANCE AND INNOVATIONS

- Inflammatory back pain was associated with MRI findings related to both axial spondyloarthritis and degeneration.
- All identified associations were weak with odds ratios ranging from 1.4-2.7.
- The results support a shift away from the historical dichotomy between inflammatory and non-inflammatory/mechanical back pain.

INTRODUCTION

Axial spondyloarthritis (axSpA) is a disabling disorder that causes inflammation in the axial skeleton with primary involvement at the sacroiliac joints (SIJs) [1]. It has traditionally been assumed that the axial inflammation associated with axSpA provokes a specific pain pattern indicative of the disease and therefore definitions of inflammatory back pain (IBP) have been incorporated into criteria for the diagnosis of axSpA [2-4] and recommendations for referral of patients with low back pain who are at risk of having axSpA [5-9]. However, the strength of the association between pain characteristics and the axSpA disease entity is debated [10].

Previous studies have shown that pain characteristics, traditionally assumed specific for axSpA, are also prevalent among patients with low back pain unrelated to axSpA [11-13]. This could be explained by axSpA not being the only cause of inflammation in the axial skeleton. Degenerative spinal disorders may also have inflammatory components, such as signal changes at the vertebral endplates (Modic changes) on magnetic resonance imaging (MRI) [14]. While vertebral endplate signal changes are relatively common in patients with low back pain [15], axSpA is a relatively rare cause of low back pain [16]. Thus, the potential association between signal changes at the vertebral endplate and IBP is an important aspect to consider when using IBP with the purpose of differentiating patients with axSpA from patients with other causes of back pain.

Recent studies investigating the association between MRI findings and IBP have shown associations between degeneration-related vertebral endplate bone marrow edema (BME) and morning stiffness, pain worst in the morning [17] and IBP (defined as pain worst in the morning, night pain or morning stiffness >60 minutes) [18]. However, these studies on the associations between MRI findings and inflammatory pain are few and of moderate sample size [17, 18]. Besides, MRI findings at the SIJs have not been included in these previous

analyses. Thus, to improve diagnosis of inflammatory spinal disorders, more knowledge is needed about the association between various causes of axial inflammation and pain characteristics.

The aim of the current study was to investigate the association between MRI findings at the SIJ and vertebral endplate and pain characteristics assumed to be indicative of axial inflammation in a cohort of young patients with persistent low back pain. This was based on the rationale that if axial inflammation causes a specific inflammatory pain, MRI findings related to axial inflammation would also be related to these specific pain characteristics, regardless of etiology.

PATIENTS AND METHODS

Patients

Data for this study were from the 'Spines of Southern Denmark' cohort, which was established to investigate the use of MRI findings in the diagnoses of low back pain and axSpA. Detailed descriptions of this cohort have been published elsewhere [19]. In brief, the cohort consists of 1,037 patients with persistent low back pain, including an unknown proportion of axSpA patients, with MRI data from the whole spine and SIJs, self-reported low back pain questionnaires and analysis of blood samples. The cohort was recruited from March 2011 to October 2013 from the Spine Centre of Southern Denmark, which is an outpatient, non-surgical unit in a secondary care public hospital setting. During the study period, the referral criteria to the Centre were an episode of back pain with a duration of 2-12 months, where conservative treatment had had insufficient effect. The secretaries responsible for the booking of appointments randomly allocated consecutive Caucasian patients referred

with low back pain to the project if they were aged 18-40 years (see Figure 1 for details). For the current analysis, only patients with information on IBP characteristics were included.

The study was conducted according to the Declaration of Helsinki-II, and before inclusion, each patient gave written informed consent for research use and publication of their de-identified data. The Regional Scientific Ethics Committee for Southern Denmark determined that under the Danish legal framework, this study did not require formal ethics approval (reference number S-20102000-58).

Demographic and clinical data

Demographic and clinical characteristics were collected using patient self-reported questionnaires completed on the first visit as part of the Spine Centre's standard procedure. Details of this procedure have been reported previously [20]. The questionnaire included items on pain duration, previous back pain episodes, back and leg pain intensity [21], present work situation, activity limitation [22, 23], and general health [24].

Inflammatory back pain data

The self-reported questionnaire also included information on single pain characteristics contained in the IBP definitions by Calin et al., Berlin, Assessment of SpondyloArthritis international Society (ASAS) and Bailly et al. [18, 25-27]. An English translation of the pain characteristics questionnaire used in the study is provided in Supplementary file 1. Whether individuals met any of the four IBP definitions was based on the presence of the individual pain characteristics (Table 1).

At the first consultation, the clinician noted information on the use of nonsteroidal anti-inflammatory drugs (NSAIDs). The effect after a full dose at 24-48 hours was noted, with the

following response options: no effect, moderate effect (the pain is somewhat improved) or good effect (the pain is gone or much better).

Magnetic resonance imaging protocol

The MRI scanning protocol has been published previously [28]. In brief, MRI of the whole spine and the SIJs was performed with a 1.5 T unit (Philips Achieva, Best, the Netherlands) MRI System. For the SIJs, the following sequences were used: semi-coronal T1-weighted TSE, semi-coronal T1-weighted acquisition with Spectral Pre-saturation Inversion Recovery (SPIR), and semi-axial T2-weighted Short-Tau Inversion Recovery (STIR). For the spine, the following sequences were used: Sagittal STIR and sagittal T1-weighted turbo spin-echo (TSE). An additional 3D Volume ISotropic T2-weighted Acquisition (VISTA) sequence and an axial T2-weighted TSE sequence were performed for the lumbar spine. Three senior consultant radiologists, who were specialists in musculoskeletal imaging and axSpA, participated in the research evaluation of the MRIs. They were blinded to all clinical information, but not from the patients' gender and age. One reader evaluated each MRI and, in the case of any uncertainties (6%), consensus was reached by consulting another reader. The MRI scan was conducted after completion of the self-reported questionnaire and the first consultation.

Magnetic resonance imaging variables

MRI findings related to both active inflammation i.e. BME as well as structural MRI findings related to late stage inflammation i.e. fatty marrow deposition (FMD), erosions and sclerosis were included in the analyses.

In the SIJ, the following findings were included: 'SIJ BME', 'SIJ FMD', 'SIJ erosions', 'SIJ sclerosis'. In the assessment of the 'SIJ BME', care was taken to avoid pitfalls that could

mimic subchondral or periarticular BME such as ligaments surrounded by blood vessels. The presence of BME at the SIJs was noted according to the definition of a positive MRI for sacroiliitis used in the ASAS criteria for axial axSpA [4].

In the spine, 'vertebral endplate BME', and 'vertebral endplate FMD' were included. In the MRI evaluation, three signal changes were assessed at the vertebral endplate: a pure BME type of vertebral endplate signal change, a pure FMD type and a mixed type (both BME and FMD). In the current study, 'vertebral endplate BME' was defined either as a pure BME type or as a mixed type of vertebral endplate signal change (both BME and FMD) and likewise, 'vertebral endplate FMD' was defined as a pure FMD type or as a mixed type of vertebral endplate signal change. Details of the MRI evaluation have been published previously [28].

The reproducibility of the MRI variables used in the current analysis was previously tested for inter- and intra-reproducibility, with kappa values ≥0.6 for inter- and intra-observer agreement except for 'SIJ erosions', which had a kappa value of 0.53 for inter-observer agreement [29].

Statistical analyses

The questionnaires and the coding of the MRI evaluations used in the current study were entered directly into a web-based registry (SpineData [20]) and were analysed using STATA 14.0 (StataCorp, College Station, Texas, USA).

Descriptive data were tabulated and reported either as proportions with 95% confidence intervals (CI) or medians with inter-quartile ranges (IQR).

Initially, the associations between MRI findings and IBP were tested with univariate analyses using a Chi Square Test. Subsequently, the associations between MRI findings and IBP were

tested with multivariable analyses using logistic regression analysis for each of the single pain characteristics and IBP definitions. The models were reduced with backwards elimination using a significance level of 5%.

RESULTS

Of the 1,037 patients in the cohort, 17 did not have information on IBP characteristics and were excluded from the current analysis, but the remaining 1,020 were included (Figure 1). The clinical and demographic characteristics of the included patients are shown in Table 2 and the prevalence of the assessed pain characteristics and MRI findings are shown in Table 3. Among the included patients, 97% (95% CI: 96%-98%) had at least one IBP characteristic and 61% (58%-64%) had at least one of the MRI findings.

Several associations between MRI findings and pain characteristics were identified in the univariate analyses with odds ratios ranging from 1.3-2.7 (See Table 4 for details). In the multivariable analyses, the odds ratios for the statistically significant associations ranged from 1.4-2.7 (See Table 5 for details). Interestingly, 'SIJ erosions' and 'vertebral endplate FMD' that are relate to late stage inflammation were more consistently associated with the pain characteristics compared to the BME findings related to active inflammation (i.e. 'SIJ BME' and 'vertebral endplate BME'). The ASAS IBP definition, and four of the single pain characteristics ('No improvement with rest', 'improvement with activity/not rest', 'pain at night with improvement upon getting up' and 'waking in the 2nd half of the night') were not associated with any of the MRI findings.

Post hoc analysis

In order to analyse the importance of the size of the signal changes in vertebral endplates (BME and FMD), *post hoc* analyses were performed, only including signal changes > 25% of

the vertebral endplate (Supplementary file 2). Overall, the magnitude of the odds ratios was similar to that in the initial analyses; however, the sum of statistically significant associations was reduced, most likely because of the lower prevalence of the findings (See Supplementary file 2 for details).

DISCUSSION

In the current study, pain characteristics assumed to be indicative of inflammation were associated with inflammatory MRI findings related to both spondyloarthritis and degeneration. Although, the identified associations were weak (OR 1.4-2.7), the results contribute to the basic understanding of axial inflammatory disorders.

Sacroiliitis is considered one of the cornerstones in the diagnosis of axSpA [4] and has for decades been assumed to cause a specific pain pattern [3, 8, 25]. In the current study, the definition of BME at the SIJs was identical to the definition of sacroiliitis included in the ASAS criteria for axSpA. Thus, IBP characteristics would be expected to correlate relatively strongly with BME at the SIJs. This was, however, not the case in the current study, as only one weak association was found between SIJ BME and one of the single pain characteristics (morning stiffness >60 min.). While erosions at the SIJ, which are considered a late stage of sacroiliitis, did associate more consistently with the IBP definitions and the pain characteristics, these associations were also weak (OR 1.8-2.7). Thus, the results from the current study suggest that MRI findings related to axSpA only correlate weakly with IBP.

Moreover, we found that BME and FMD at the vertebral endplate (i.e. Modic changes type 1 and 2) were associated with pain characteristics traditionally assumed specific for axSpA. Two previous studies in patients with chronic low back pain have reported similar associations between vertebral endplate BME and ‘pain worst in the morning’ and ‘morning

stiffness' [17] and the definition of IBP defined by Bailly et al. [18]. Collectively, these results question axSpA as the only cause of IBP, as vertebral changes related to degeneration also are associated with pain characteristics historically assumed specific to axSpA. These results may further explain why studies investigating the association between the clinical diagnoses of axSpA and pain characteristics also report weak associations [11-13].

Interestingly, MRI findings related to late stage inflammation, i.e. 'SIJ erosions' and 'vertebral endplate FMD' were more consistently associated with the assessed pain characteristic than BME findings related to active inflammation. It is possible that, a certain degree of inflammation is needed to result in structural changes such as FMD and erosions. Thus, an explanation for the more consistent associations between the structural findings and IBP may be that these findings represent a more severe inflammatory process. However, the current study did not include information on temporality between the inflammatory MRI findings and pain characteristics and further studies are needed to provide knowledge on the causal pathways of this association.

Another interesting finding of the study, was that almost all patients in this population of patients with persistent low back pain (97%) had at least one of the IBP characteristics. Moreover, several of the single pain characteristics i.e. 'insidious onset', 'night pain', 'no improvement with rest' and 'morning stiffness' were each reported by 50-75% of the patients. These results underline that some of the pain characteristics historically assumed indicative of inflammation are generally very common in patients with persistent low back pain.

Collectively, the results from this study challenge the historical view of degeneration as a simple 'wear and tear' condition. This view was established several decades ago, but our understanding of inflammation and the role of inflammatory mediators in musculoskeletal

pain disorders has advanced extensively since then [30, 31]. The inflammatory components in a variety of spinal degenerative changes have been established from several studies, which offer a more complex view of spinal degenerative disorders [32-34]. Thus, the dichotomy between inflammatory and non-inflammatory/mechanical back pain might not be as straightforward as previously believed.

The methodological strengths of the current study are firstly that the standardised definitions and data collection methods increased the validity of the data. Secondly, to reduce the risk of circularity bias, the completion of the IBP questionnaire was performed prior to the MRI scans and the MRI evaluations were blinded to all clinical and demographic information, except age and gender. Moreover, the MRI evaluation included both the SIJs and the whole spine, making it possible to assess inflammatory findings in the most important regions of the axial skeleton. Lastly, the study results were strengthened by the large study sample involving an unselected back pain population representative of the diagnostic challenges of persistent low back pain including early axSpA.

There are also important limitations of the current study. Firstly, the formulation of a standardised questionnaire required creating operational definitions for the IBP characteristics, because no validated self-reported questionnaire including the assessed items existed when the study was initiated. Secondly, the validity of the ASAS definition of a positive MRI for sacroiliitis, used in the current study to define BME at the SIJ, is currently debated [35] and BME at the SIJ may have causes other than axSpA. However, it was not within the scope of the current study to evaluate the diagnostic accuracy of IBP relative to the diagnosis of axSpA, but rather to evaluate IBP relative to inflammation-related MRI findings broadly. This was based on the rationale that if axial inflammation causes a specific inflammatory pain, MRI findings related to axial inflammation would also be related to these

specific pain characteristics, regardless of etiology. However, conclusions regarding the diagnostic accuracy of IBP in relation to the clinical diagnosis of axSpA cannot be drawn from the current study. Another limitation of this study is that all inflammatory changes might not be visualised by MRI. Currently, MRI is regarded as the imaging modality best capable of visualising inflammatory changes in the spine and SIJ; however, early or low-grade inflammatory changes might not be detectable with MRI [36]. Finally, in order not to exclude relevant findings, we included all vertebral endplate signal changes which may have increased the risk of including small clinically irrelevant findings. However, modifications of the cut point of the size of the signal changes to > 25% of the vertebral endplate did, overall, not seem to change the strength of the association with IBP.

Overall, the associations between inflammatory MRI findings and pain characteristics found in the current study indicate, that in some cases axial inflammation induces a specific pain pattern. Thus, the results add to the basic knowledge of axial inflammatory processes. However, all identified associations were weak, which compromise the use of IBP as a marker of axial inflammation in clinical practice. Moreover, as associations were found between MRI findings related to both spondyloarthritis and degeneration, the results support a shift away from the historical view of a dichotomy between inflammatory and non-inflammatory/mechanical back pain.

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Table 1. Definitions of inflammatory back pain

Calin, 1977 [25]	Berlin, 2006 [26]	ASAS, 2009 [27]	Bailly, 2014 [18]
At least four out of five of: – Back pain >3 months – Age at onset <40 years – Insidious onset – Morning stiffness – Improvement with exercise	Mandatory: – Back pain >3 months At least two out of four of: – Morning stiffness >30 min. – Improvement with exercise but not with rest – Waking in the 2nd half of the night because of back pain – Alternating buttock pain	Mandatory: – Back pain >3 months At least four out of five of: – Age at onset <40 years – Insidious onset – Improvement with exercise – No improvement with rest – Pain at night (with improvement upon getting up)	At least one of three of: – Night pain – Morning stiffness >60 min. – Pain worst in the morning

Table 2. Prevalence of demographic and clinical characteristics in the included patients.

Characteristics	
Age in years, median (IQR), n=1020	33 (27-37)
Women, % (95% CI), n=1020	54 (50-57)
Employed, % (95% CI), n=949	71 (68-74)
Sick leave[§], % (95% CI), n=849	50 (47-54)
Previous LBP episode(s), % (95% CI), n=958	74 (72-77)
LBP duration (months), median (IQR), n=955	11 (4-39)
LBP intensity, median (IQR), n=964	6 (5-7)
Leg pain, % (95% CI), n=876	27 (24-30)
Activity limitation (RMDQ), median (IQR), 948	57 (39-74)
General health (EuroQol VAS), median (IQR), n=962	52 (38-74)

n varies in each analysis due to missing values, LBP: low back pain, LBP intensity is averaged 0–10 Numerical Rating Scale (NRS) on current LBP, worst LBP last 14 days and typical LBP last 14 days, RMDQ: Roland Morris Disability Questionnaire (calculated as a proportional score (0% = no activity limitation; 100% = maximum activity limitation), VAS: visual analogue scale, §: Sick leave due to back pain 3 months before first consultation

Table 3. Prevalence of the assessed pain characteristics and MRI-findings in the included patients.

Inflammatory back pain definitions	
Calin, n=999	40 (37-43)
Berlin, n=968	32 (29-35)
ASAS, n=1001	17 (15-19)
Bailly, n=987	79 (76-81)
Single inflammatory back pain characteristics	
Insidious onset, n=1009	52 (49-55)
Improvement with exercise, n=997	20 (18-23)
No improvement with rest, n=985	69 (66-72)
Improvement with exercise/not rest, n=981	16 (13-18)
Pain at night, n=1001	72 (69-74)
Improvement upon getting up	31 (29-34)
Waking in the 2nd half of the night	39 (36-42)
Morning stiffness, n=1008	76 (73-78)
> 30 min	49 (46-52)
> 60 min	25 (23-28)
Pain worst in the morning, n=954	10 (8-12)
Alternating buttock pain, n= 884	27 (24-30)
Good response to NSAIDs, n=702	21 (18-24)
MRI findings	
SIJ BME, n=1020	21 (19-24)
SIJ erosions, n=1020	8 (6-9)
SIJ FMD, n=1020	14 (12-16)
SIJ sclerosis, n=1020	8 (6-9)
Vertebral endplate BME, n=1020	34 (31-37)
Vertebral endplate FMD, n=1020	38 (35-41)

Values are percentages with 95% confidence intervals in parentheses. ASAS: Assessment of SpondyloArthritis international Society, NSAIDs: non-steroidal anti-inflammatory drugs, SIJ; sacroiliac joint, BME: bone marrow edema, FMD: fatty marrow deposition

Table 4 Univariate analyses of the association between MRI findings and inflammatory back pain definitions and single pain characteristics.

	Sacroiliac joints				Vertebral endplate	
	BME	Erosions	FMD	Sclerosis	BME	FMD
Inflammatory back pain definitions						
Calin, n=999	1.4 (1.0-1.8)	**1.9 (1.2 -3.0)***	**1.6 (1.1-2.3)***	1.2 (0.7-1.8)	**1.3 (1.0-1.7)***	**1.4 (1.1-1.8)***
Berlin, n=968	1.3 (1.0-1.8)	**1.9 (1.2-3.1)***	1.0 (0.7-1.5)	0.9 (0.6-1.5)	1.3 (0.9-1.7)	1.1 (0.9-1.5)
ASAS, n=1001	1.2 (0.8-1.8)	1.4 (0.8-2.5)	1.4 (0.9-2.2)	1.3 (0.7-2.3)	1.0 (0.7-1.5)	1.3 (0.9-1.8)
Bailly, n=987	**1.7 (1.1-2.6)***	**2.7 (1.2-6.0)***	1.5 (0.9-2.4)	**2.1 (1.0-4.3)***	**1.6 (1.2-1.5)***	**1.6 (1.2-2.3)***
Single inflammatory back pain characteristics						
Insidious onset, n=1009	1.3 (1.0-1.8)	1.5 (0.9-2.5)	**1.5 (1.0-2.2) ***	1.1 (0.7-1.7)	1.1 (0.9-1.4)	1.1 (0.9-1.4)
Improvement with exercise, n=997	1.1 (0.7-1.6)	0.9 (0.5-1.6)	0.9 (0.5-1.4)	0.7 (0.4-1.3)	1.2 (0.9-1.7)	**1.6 (1.1-2.1)***
No improvement with rest, n=985	1.1 (0.8-1.5)	1.5 (0.9-2.7)	1.3 (0.9-1.9)	1.4 (0.8-2.5)	1.1 (0.9-1.5)	0.8 (0.6-1.1)
Improvement with exercise/not rest, n=981	1.2 (0.8-1.7)	1.1 (0.6-2.1)	1.0 (0.6-1.6)	0.8 (0.4-1.6)	1.2 (0.8-1.7)	1.3 (0.9-1.9)
Pain at night, n=1001	1.3 (0.9-1.8)	**1.9 (1.1-3.7)***	1.3 (0.9-2.1)	**2.3 (1.2-4.4)***	1.1 (0.9-1.5)	1.1 (0.8-1.5)
Improvement upon getting up	1.1 (0.8-1.6)	1.2 (0.7-2.0)	1.3 (0.9-1.8)	1.2 (0.8-2.0)	0.8 (0.6-1.1)	0.9 (0.7-1.2)
Waking in the 2nd half of the night	1.3 (1.0-1.8)	1.3 (0.8-2.2)	1.0 (0.7-1.4)	1.1 (0.7-1.7)	1.1 (0.8-1.4)	1.0 (0.7-1.2)
Morning stiffness, n=1008	1.2 (0.8-1.7)	1.6 (0.8-2.9)	1.3 (0.9-2.1)	1.0 (0.6-1.6)	**2.0 (1.4-2.8)***	**1.7 (1.2-2.3)***
> 30 min	**1.4 (1.0-1.9)***	1.3 (0.8-2.1)	1.3 (0.9-1.9)	1.0 (0.6-1.6)	**1.4 (1.0-1.8)***	**1.4 (1.1-1.9)***
> 60 min	**1.4 (1.0-2.0)***	1.2 (0.7-2.0)	1.1 (0.7-1.6)	0.7 (0.4-1.3)	1.1 (0.8-1.5)	1.1 (0.9-1.5)
Pain worst in the morning, n=954	1.2 (0.7-1.9)	0.7 (0.3-1.8)	0.9 (0.5-1.7)	0.8 (0.3-1.9)	**1.6 (1.1 -2.5)***	**2.0 (1.3-3.1)***
Alternating buttock pain, n= 884	1.2 (0.8-1.7)	**1.8 (1.0-2.9)***	1.4 (0.9-2.1)	**1.7 (1.0-2.7)***	0.8 (0.6-1.1)	0.8 (0.6-1.1)
Good response to NSAIDs, n=702	1.1 (0.7-1.7)	**2.3 (1.3-4.3)***	1.3 (0.8-2.1)	0.9 (0.4-1.8)	1.0 (0.7-1.5)	1.1 (0.7-1.6)

Values are presented as odds ratios with 95% confidence intervals in parentheses. * p-value<0.05. BME: bone marrow edema, FMD: fatty marrow deposition, ASAS: the Assessment of SpondyloArthritis international Society, NSAIDs: non-steroidal anti-inflammatory drugs

Table 5. Multivariable analyses of the association between MRI findings and inflammatory back pain definitions and single pain characteristics.

	Sacroiliac joint				Vertebral endplate	
	BME	Erosions	FMD	Sclerosis	BME	FMD
Inflammatory back pain definitions						
Calin, n=999	-	1.9 (1.2-3.0)	-	-	-	1.4 (1.1-1.8)
Berlin, n=968	-	1.9 (1.2-3.0)	-	-	-	-
ASAS, n=1001	-	-	-	-	-	-
Bailly, n=987	-	2.7 (1.2-6.0)	-	-	-	1.6 (1.2-2.3)
Single inflammatory back pain characteristics						
Insidious onset, n=1009	-	-	1.5 (1.1-2.2)	-	-	-
Improvement with exercise, n=997	-	-	-	-	-	1.6 (1.1-2.1)
No improvement with rest, n=985	-	-	-	-	-	-
Improvement with exercise/not rest, n=981	-	-	-	-	-	-
Pain at night, n=1001	-	-	-	2.3 (1.2-4.3)	-	-
Improvement upon getting up	-	-	-	-	-	-
Waking in the 2nd half of the night	-	-	-	-	-	-
Morning stiffness, n=1008	-	-	-	-	2.0 (1.4-2.8)	-
> 30 min	-	-	-	-	-	1.4 (1.0-1.9)
> 60 min	1.4 (1.0-2.0)	-	-	-	-	-
Pain worst in the morning, n=954	-	-	-	-	-	2.0 (1.3-3.0)
Alternating buttock pain, n= 884	-	1.8 (1.0-2.9)	-	-	-	-
Good response to NSAIDs, n=702	-	2.3 (1.3-4.3)	-	-	-	-

Values are presented as odds ratios with 95% confidence intervals in parentheses. Each row represents a logistic regression analysis with the relevant IBP variable as outcome, n varies in each analysis due to missing values. Only MRI finings with p-values < 0.05 were included in the final model. BME: bone marrow edema, FMD: fatty marrow deposition, ASAS: the Assessment of SpondyloArthritis international Society, NSAIDs: non-steroidal anti-inflammatory drugs.

Figure 1. Flow-chart of the exclusion and inclusion of participants in the study from the Spines of Southern Denmark (SSD) cohort. MRI: magnetic resonance imaging, LBP: low back pain.